mmWave Coalition
Supplemental Submission
of
November 30, 2019

https://ecfsapi.fcc.gov/file/113010791160/Ex%20Parte%20Supplement%20of%20mmWave%20Coalition%20FINAL.pdf

www.mmwavecoalition.org

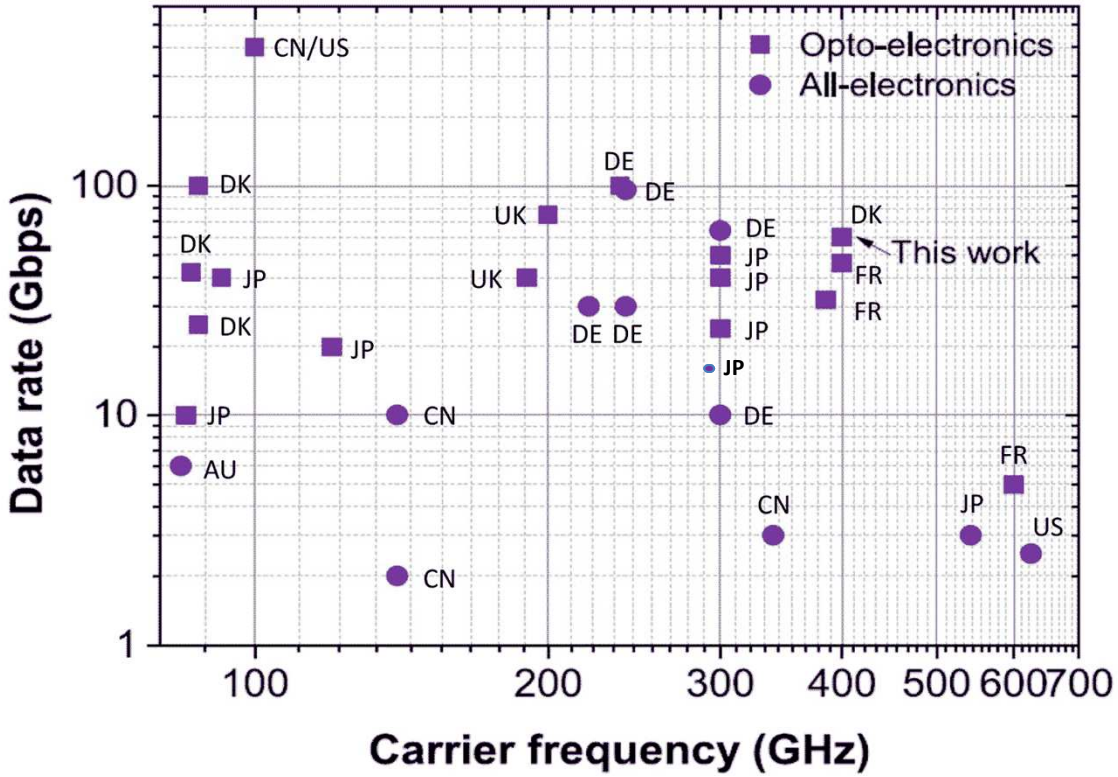
December 18, 2018

mmWave Coalition Members

The mmWC is a group of innovative companies and universities united in the objective of removing regulatory barriers to technologies using frequencies ranging from 95 GHz to 275 GHz.

- American Certification Body, Inc.
- Azbil North America R&D, Inc.
- GlobalFoundries U.S. Inc.
- Keysight Technologies, Inc.
- Nokia
- Nuvotronics, Inc.
- NYU Wireless
- Qorvo, Inc.
- RaySecur
- Virginia Diodes, Inc.

Published Data on Worldwide mmW/THz System Experiments



- R&D, often with national government support, is underway around the world as high as 600 GHz!
- **But little from US!**
- **Why? Impact of uncertain spectrum policy?**

Yu, Asif, *et al.*, "400-GHz Wireless Transmission of 60-Gb/s Nyquist-QPSK Signals Using UTC-PD and Heterodyne Mixer," *IEEE Transactions on Terahertz Science and Technology*, Issue No. 99, p. 1-6 (August 2016) (http://ieeexplore.ieee.org/document/7556985/)
Update - https://www.sciencedaily.com/releases/2017/02/170205190911.htm

mmW/THz Communications Possibilities

- Cellular backhaul – in certain cases
  - High capacity cell sites will need a lot of backhaul
  - Fiber is cheapest ***if*** fiber is in the ground already
  - BUT in some places fiber installation is slow and very expensive
- Mobile broadband
- Temporary restoration of fiber links in disasters
- Temporary fixed communications for special events & disaster recovery

Why mmW/THz

- One of the primary benefits of spectrum bands above 95 GHz is the potential for wide-bandwidths unmatched in other bands allocated by the Commission.
- **BUT**

Existing Bands Created in 2003

Band (GHz)	Total Bandwidth (GHz)
71-76	5.0
81-86	5.0
92-95	3.0

Docket 18-21 NPRM Bands

Band (GHz)	Total Bandwidth (GHz)
95-100	5.0
102-109.5	7.5
111.8-114.25	2.45
122.25-123	0.75
130-134	4.0
141-148.5	7.5
151.5-158.5	7.0
174.5-174.8	0.3
231.5-232	0.5
240-241	1.0

Impact of US246

- US246 is closely related to ITU fn. 5.340
  - But RR 4.4 gives US flexibility *if* it protects primary allocations
- Both are decades old in their current structure
- Below 50 GHz the prohibitions here have little practical impact on spectrum policy
  - Of 83 mostly contiguous original TV channels only 1 was impacted
- Below 50 GHz anomalous propagation, *e.g.* ducting, and inability to focus power well were good justifications for absolute prohibition in such bands

Regulations Impact on Spectrum Above 95 GHz

5.340 All emissions are prohibited in the following bands:

1400-1427 MHz,
2690-2700 MHz, except those provided for by No. 5.422,
10.68-10.7 GHz, except those provided for by No. 5.483,
15.35-15.4 GHz, except those provided for by No. 5.511,
23.6-24 GHz,
31.3-31.5 GHz,
31.5-31.8 GHz, in Region 2,
48.94-49.04 GHz, from airborne stations
50.2-50.4 GHz[2],
52.6-54.25 GHz,
86-92 GHz,
100-102 GHz,
109.5-111.8 GHz,
114.25-116 GHz,
148.5-151.5 GHz,
164-167 GHz,
182-185 GHz,
190-191.8 GHz,
200-209 GHz,
226-231.5 GHz,
250-252 GHz.

US246 No station shall be authorized to transmit in the following bands:

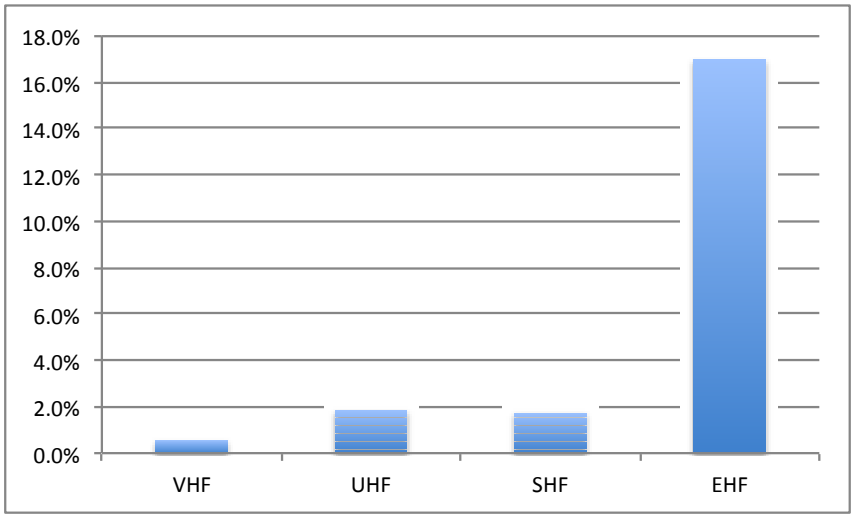
73-74.6 MHz,
608-614 MHz, except for medical telemetry equipment 1 and white space devices,
1400-1427 MHz,
1660.5-1668.4 MHz,
2690-2700 MHz,
4990-5000 MHz,
10.68-10.7 GHz,
15.35-15.4 GHz,
23.6-24 GHz,
31.3-31.8 GHz,
50.2-50.4 GHz,
52.6-54.25 GHz,
86-92 GHz,
100-102 GHz,
109.5-111.8 GHz,
114.25-116 GHz,
148.5-151.5 GHz,
164-167 GHz,
182-185 GHz,
190-191.8 GHz,
200-209 GHz,
226-231.5 GHz,
250-252 GHz.

Is absolute prohibition actually needed above ~ 50 GHz?

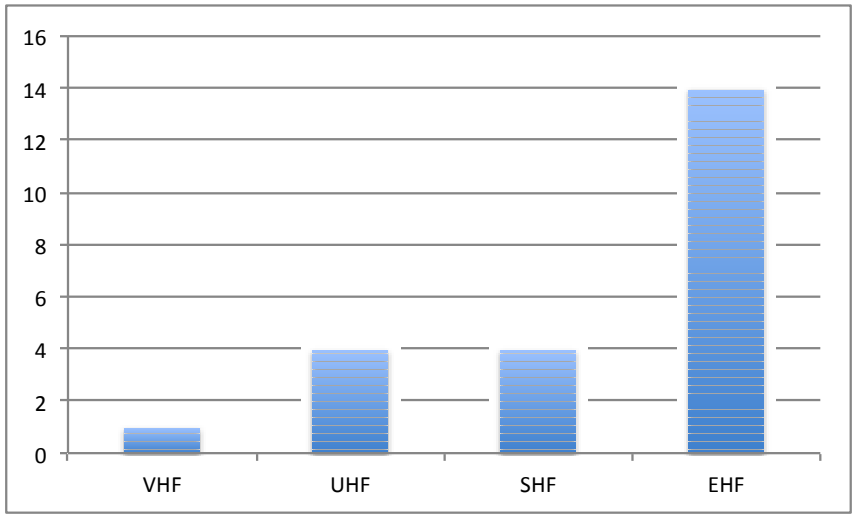
Impact of US246:

At EHF these bands have a major impact on spectrum availability totally unlike the lower bands

Size of forbidden bands



Number of forbidden bands



Impact of US246

Lower Band Edge (GHz)	Upper Band Edge (GHz)	Bandwidth (GHz)	Non-US246 Bandwidth to Next US246 Band (GHz)
100	102	2	7.5
109.5	111.8	2.3	2.45
114.25	116	1.75	32.5
148.5	151.5	3	12.5
164	167	3	15
182	185	3	5
190	191.8	1.8	8.2
200	209	9	17
226	231.5	5.5	18.5
250	252	2	

- Limits maximum bandwidth below 275 GHz to 32.5 GHz
  - Note, even that is not proposed in NPRM!

Mystery of Japanese 116-134 GHz Band

- NPRM para. 12:
  - "in 2014, Japan's Ministry of Internal Affairs and Communications officially revised its radio regulations to allocate an 18 gigahertz-wide band at 116 GHz to 134 GHz to accommodate such service."
  - More than twice the bandwidth of large band in NPRM
- Why isn't there a comparable band in this NPRM?

Even without US246 protection some bands appear to be “off limits”

116-122.25 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.562C SPACE RESEARCH (passive) 5.138 5.341 US211		ISM Equipment (18)
122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 5.138	122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 Amateur 5.138	ISM Equipment (18) Amateur Radio (97)
123-130 FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) RADIONAVIGATION RADIONAVIGATION-SATELLITE Radio astronomy 5.554 US211 US342		
EARTH EXPLORATION-SATELLITE (active) 5.562E FIXED INTER-SATELLITE MOBILE 5.558 RADIO ASTRONOMY 5.562A US342		

237 GHz Issue
Europe Example

http://spectrum.ieee.org/telecom/wireless/a-new-record-for-terahertz-transmission

A New Record for Terahertz Transmission

Engineers achieve amazing data rates in a once-inaccessible band

By Lily Hay Newman
Posted 28 Nov 2013 | 20:30 GMT

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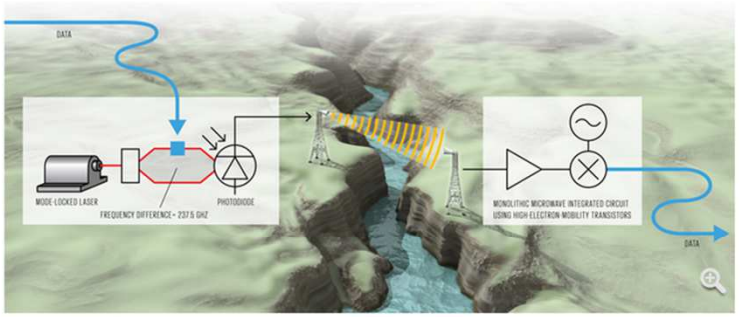

Illustration: Emily Cooper

Bridging a Gap: Two components from the beam of a mode-locked laser shine on a photodiode to produce near-terahertz radiation. A monolithic microwave IC receives the signal and extracts the data.

The problem with the radio spectrum between 3 and 3000 megahertz is that it's crowded. Television, radio, mobile phones, Bluetooth, GPS, two-way communication devices, and Wi-Fi all operate in this high- to ultrahigh-frequency range. So with nowhere to go but up, researchers have been working for decades to utilize the 3- to 3000-gigahertz span. In October, a team reported a hopeful sign—a record 100-gigabit-per-second wireless data transmission.

Scientists in Germany, at the Karlsruhe Institute of Technology (KIT), the Fraunhofer Institute for Applied Solid State Physics, and the University of Stuttgart, created a wireless connection between a transmitter and a receiver that were 20 meters apart at a frequency of 237.5 GHz. This frequency is in

- Why was this done in Germany not USA?
- Would NTIA/IRAC concur on such an experiment?
  - Not likely based on recent precedents!
- Isn't what's good for the GDP, good for scientific research *if* win/win sharing solutions are found?

235-238
EARTH EXPLORATION-SATELLITE (passive)
FIXED-SATELLITE (space-to-Earth)
SPACE RESEARCH (passive)
5.563A 5.563B

“Off limits bands” and their impact on R&D

- Opening the full range of 116-148.4 GHz for communication use would help justify a business case for their R&D in this spectral range since it would be easier to segment this range between multiple uses
- Protection of cochannel allocations should be on quantitative protection criteria NOT prohibitions extrapolated from much lower bands decades ago

EHF Wi-Fi

- Standard created recently in IEEE 802.15.3d for global Wi-Fi use at frequencies above 250 GHz and is likely to first be used in the 252 to 275 GHz spectrum bands
  - Adjacent to US246 band at 250-252 GHz

- IEEE 802.15.3d-2017 standard was approved on September 28, 2017 and was published on October 12,2018 as the worldwide first wireless communications standard for the 250 – 350 GHz frequency range.

Proposal for Updating US246

- Bases protection of vital passive systems on quantitative signal limit at EESS locations to incentivize R&D, improve transparency, and decrease regulatory uncertainty for US developers
- Builds on existing ITU-R protection criteria
  - Allows for tighter criteria if US is proposing such to ITU-R during its pendency

Proposed update

Footnotes omitted

US246 No station shall be authorized to transmit in the following bands: 73-74.6 MHz, 608-614 MHz (except for medical telemetry equipment and white space devices),1400-1427 MHz, 1660.5-1668.4 MHz, 2690-2700 MHz, 4990-5000 MHz, 10.68-10.7 GHz, 15.35-15.4 GHz, 23.6-24 GHz, 31.3-31.8 GHz, 50.2-50.4 GHz, 52.6-54.25 GHz, 86-92 GHz.

In 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz, all stations are generally forbidden; however, the Commission and NTIA will issue licenses or assignments only under mutually agreed procedures that assure that authorized Radio Astronomy Service facilities and Earth Exploration Satellite Service stations are protected from both the individual and aggregate emissions to the criteria given in ITU-R RS.2017, ITU-R RS.1858, ITU-R RA.517, ITU-R RA.517, ITU-R RA.611, ITU-R RA. 769-2 and ITU-R RA.1031.

In cases where there is a formal coordinated Commission/NTIA/DOS US proposal to ITU-R to adopt a stricter standard protection limit, that draft position will apply as long as the draft is pending in ITU-R

Other mmW/THz Possible Uses

- THz spectroscopy
  - Reflections give spectroscopic information about nature of object
  - Wide bandwidth systems can measure small distances very precisely
    - Plywood thickness on factory production lines
    - Coatings of medicine pills
    - Verify “special” coatings on aircraft & submarines
  - Used in NASA Space Shuttle program to verify safety critical heat tile adhesion to spacecraft

THz Spectroscopy Uncertainty

- NPRM:
  - "[w]e are aware of interest in using the spectrum above 95 GHz for devices that use terahertz spectroscopy to analyze material properties and for imaging applications, which could possibly be considered ISM applications"
  - "While the Office of Engineering and Technology currently evaluates (THz spectroscopy)applications for devices that use the frequencies above 95 GHz on a case-by-case basis …"
    - fn. 151 points to a KDB statement

- Yet proposals gives only uncertainty to products presently sold or for new ones

Current Products

- ADVANTEST TAS7500 Series Terahertz Spectroscopic / Imaging System
  - "The TAS7500 series is a family of compact and multipurpose terahertz spectroscopic / imaging systems. Utilizing the unique properties of the terahertz region (0.1 – 10.0THz) of the electromagnetic spectrum, these systems perform non-destructive analysis of pharmaceuticals, chemicals, communications materials, etc., without requiring a specially constructed analysis environment. Speed and ease of operation are the hallmarks of Advantest's terahertz analysis systems. In addition to industrial applications, the TAS7500 series is also an optimal choice for terahertz – related research, leveraging Advantest's high-precision detection technology to provide best-in-class sampling performance".

https://www.advantest.com/products/terahertz-spectroscopic-imaging-systems/tas7500-series-terahertz-spectroscopic-/-imaging-system

- LUNA Luna Innovations/Advanced Photonix T-Gauge®
- "T-Gauge® Picometrix sensor is the first web scanning Time Domain Terahertz solution for plant floor deployment to measure basis weight, caliper, density, moisture on laminated and multi-layer composites. Terahertz technology previously limited to research facilities, military, aerospace and homeland security is now available to the industrial web processing market."
- US Regulatory status – "complicated"

http://lunainc.com/thz/products/t-ray5000

Today's THz Spectroscopy **ACTUAL** uses

- NASA and military are *actual users* of this technology although it appears that NTIA has no policy
- Record reveals that TeraMetrix, a US company, is in serial production of this product <u>in competition with firms around the world</u>
  - Has been supplying military & NASA as well as commercial customers in low tech production industries where their devices allow for real time QC of fast moving products on production lines

Conclusions

- Wideband communications and THz spectroscopy uses above 95 GHz offer new opportunities not available in lower bands
- THz spectroscopy offers unique noncommunications short range sensing capabilities and is in actual use today even though regulatory status is “fuzzy”
- “Painting stripes on highway” urgently needed to let US firms compete in world markets and “to make available, so far as possible, to all the people of the United States, … a rapid, efficient, Nation-wide, … radio communication service with adequate facilities at reasonable charges”